Biomass Burning and Aerosol Characteristics in India

Pawan Gupta (STI/USRA at MSFC),
Robert Levy (GSFC),
Anton Darmenov (GSFC),
Falguni Patadia (GESTAR/USRA/GSFC),
Lorraine Remer (UMBC/GSFC), and
Krishna P. Vadrevu (SERVIR/MSFC)

Collaborator: Mukesh Sharma (Indian Institute of Technology, Kanpur, India), Yogesh Kant (Indian Institute of Remote Sensing, Dehradun, India)
Introduction

An estimated 6.5 million deaths were associated with air pollution in 2012. This is 11.6% of all global deaths.

WHO Report

Fourteen out of the world's most-polluted 20 cities are in India

<table>
<thead>
<tr>
<th>City</th>
<th>*PM2.5</th>
<th>City</th>
<th>*PM2.5</th>
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<tbody>
<tr>
<td>Kanpur</td>
<td>173</td>
<td>Gurgaon</td>
<td>113</td>
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<tr>
<td>Faridabad</td>
<td>172</td>
<td>Jaipur</td>
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<td>Varanasi</td>
<td>151</td>
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<td>Ulaanbaatar</td>
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<td>Lucknow</td>
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<td>Hengshui</td>
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<td>Anyang</td>
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<tr>
<td>Srinagar</td>
<td>113</td>
<td>Liaocheng</td>
<td>86</td>
</tr>
</tbody>
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*(Annual mean, µg/m3)

Source: World Health Organization

Can be seen from a million miles away

Air Pollution Affects Nearly All of Us

Surface

24-Hour Mean (PM2.5 Mass Concentration)
Four plus decades of research over India

Aerosol Properties

- Photometery aboard rocket
- INDOEX field campaign
- Regional field campaign
- Decadal change in aerosols from satellite
Several studies have been published that identify dust, biomass burning, biofuels, vehicular and industrial pollution as dominant sources of aerosols in the region but their relative contribution remain unknown.
Four plus decades of research over India

Over the year aircrafts have been used to measure vertical profiles of aerosols and its properties along with CALIPSO over last decade.
Four plus decades of research over India

Aerosol Properties
Aerosol Sources
Vertical Distribution
Transport

Focused on spring-summer time dust and postmonsoon smoke transport
In order to understand the changing nature of aerosols and its implications for AQ and regional radiation budget, continuous monitoring of aerosols is required.
Moving Forward
Characterizing Nearly Two Decades of Biomass Burning Over The Indian Sub-Continent Using Satellite, Surface and Model Simulations

Satellite Measurements

- MODIS
  - Aerosols
  - Fires
- VIIRS
  - Aerosols
  - Fires
- CERES
  - Flux

Biomass Burning and Aerosol Characteristics over Indian Sub-Continent

Surface Measurements

- PM2.5 Mass Concentration
  - Regulatory Measurements
  - Low-Cost Measurements
- AERONET
  - AOD
  - Size Distribution
  - Absorption

Model Simulations

- GEOS-5
  - Emissions
  - Specific Fire Event Simulations
  - Biomass burning impact Analysis

Scientific Publications

Online Visualization and Analysis Tool

Outcome

Capacity Building

Task #1
• Satellite Product Evaluation

Task #2
• Special Aerosol Retrievals

Task #3
• Spatial and Temporal Fire Burning Trends

Task #4
• Impact of Fires on Atmospheric Aerosols

Task #5
• Column to Surface Relationships and Air Quality

Task #6
• Estimation of Aerosol Direct Radiative Effects

Task #7
• Long-term Trends in PM2.5, AOD and ARE

GSFC
MSFC
TEAM
USRA
UMBC
ISRO
IIT

IIT ISRO
We plan to validate MODIS (DT, DB, MAIAC) and VIIRS (750 m) AODs before using for AQ & Radiative forcing.
High Resolution Gridded Product

MODIS–TERRA AOD at 550 nm: 200002

Visualization tool for this data is under development
IGP is highly influenced by mineral dust during premonsoon and sea salt during monsoon, while during postmonsoon fine mode aerosols dominate.
VIIRS fires detected on March 28, 2016 (left) and Nov. 2, 2016 (right). In March we see much burning in central and southern India (agricultural and open fires) and some fires in the IGP and Nepal (forest fires). On Nov 2nd, 2016 the fires have migrated to Northern India, and Pakistan (Image Generated using Worldview).

Agricultural fires show bimodal trend corresponding to Rice-Wheat residue burning
Vegetation Fires in South Asia

India accounts for 81% of the total vegetation fires in South Asia.

Trends in vegetation fires over different South Asian countries suggest a decreasing trend (Vadrevu et al., 2018 ERL, submitted).
Surface vs Column

Leveraging NASA Citizen Science Project – Deploying Low-Cost AQ sensors in India
Impact of Biomass Burning on Air Quality

Satellite and Surface Measurements Respond to Change in Air Quality During Fires in CA

Gupta et al., 2018

VIIRS Fire Counts & PM2.5 – Delhi, India

Gupta et al., 2018
**Model Simulation - November 06, 2016**

- **GEOS experiments**
  - Experiment 1: Full set of emissions
  - Experiment 2: No biomass burning emissions

**Goals:**
- Estimate contributions due to fires, dust and other sources
- Identify biases in the forward model
- Correct the biases in PM2.5 and find the contribution of the fires to the AQIs
Challenges & Approaches

• Various visual satellite images and correlation analysis suggests the impact of fires on aerosol loading, there is little direct proof.

• during the post monsoon season, aerosols originate not only from crop burning, but also from domestic heating (due to cold temperature) and industrial & vehicular pollution.

• during the spring/summer fire season, dust is added to the mix, which create another layer of complexity and requires a different approach.

  – Long-term background aerosol climatology. This background should include all “normal” particle producing activity, with fires adding an “abnormal” positive perturbation to these values.
  – Explore multiple spectral/spatial tests to identify and retrieve smoke aerosol optical depth
  – CALIPSO climatology of aerosol typing will also be explored
  – Model simulations with improved emission data sets
Summary

• The ISC is suffering from overwhelming burdens of particulate air pollution and creating significant radiative perturbations to the regional and perhaps global energy balance.

• How much of this burden is due to smoke from fires?

• How has the contribution from biomass burning changed over the years?

• How can we inform policy decisions that will begin to mitigate this burden and perturbation?

- With nearly two decades of satellite aerosol and fire detection products, advanced global modeling system, combined with a network of ground measurements in the region, we aim to begin to answer some of these questions.